# Navy METOC Modeling

**ESPC Workshop**

**21 March 2012**

**Steven Payne**

# Production Centers

- Fleet Numerical Meteorology and Oceanography Center
  - Monterey CA
  - Linux Clusters
    - Current - 5348 Cpus / 56 Tflops
    - Projected FY12 – 7648 Cpus / 81 Tflops
- Naval Oceanographic Office
  - Stennis Space Center MS
  - Navy HPCMO DSRC (15% Operational)
    - Current – IBM Power 5+, 6, Cray XT5: 19328 cores / 221 Tflops
    - Projected FY 12 - 33600 cores / 672 Tflops
    - Projected FY 14 – 1700 to 2000 Tflops

# Models Overview
# Atmosphere

- Navy Operational Global Atmospheric Prediction System (NOGAPS)
- Navy Atmospheric Variational Data Assimilation System – Accelerated Representer (NAVDAS-AR)
- Navy Global Environmental Model (NAVGEM)
- Ensemble Forecast System (EFS)
- Navy Aerosol Analysis and Prediction System (NAAPS)
- Coupled Ocean-Atmosphere Mesoscale Prediction System (COAMPS)
  - COAMPS NAVDAS
  - COAMPS-OnScene (OS)
  - COAMPS-Tropical Cyclone (TC)
- Geophysical Fluid Dynamics Laboratory Tropical Cyclone Model (GFDN)
- Advanced Climate Analysis and Forecasting System (ACAF)

# Models Overview
# Ocean

- Global Navy Coastal Ocean Model (G-NCOM)
- Global Hybrid Coordinate Ocean Model (G-HYCOM)
- Relocatable Navy Coastal Models (R-NCOM)
- Arctic Cap Nowcast Forecast System (ACNEFS)
- Wave Models – SWAN, WAM, and Wave Watch 3
- Coupled Ocean-Atmosphere Mesoscale Prediction System (COAMPS)
  - COAMPS/NCOM
- Coastal and Estuarine Models – DELFT 3D and ADCIRC
- Tide Models – PC Tides, ADCIRC, and OTIS
- Navy Coastal Ocean Data Assimiliation – NCODA (3DVar)

# NAVGEM Current Status

## (Version 1.0)

| | |
|---|---|
| **Data Assimilation** | • Variational bias correction for radiance data<br>• NASA Land Information System (LIS) |
| **Dynamics** | • Semi-Lagrangian/Semi-implicit advection<br>• T359L42 (37km)<br>• Three-time level integration, Time step 360s<br>• Ozone prediction |
| **Physics** | • Simplified Arakawa Schubert scheme for cumulus parameterization<br>• Shallow convection scheme<br>• Adjustment of gravity wave drag<br>• Reduction of enhanced surface roughness over land |

# NAVGEM FY12

- **Development of NAVGEM (SL/SI)**
  - New dynamic core with SL/SI scheme
  - Higher resolutions, larger time step
  - New advection of potential temperature
  - Advanced physics
    - SAS convective Scheme
    - Shallow convection
    - RRTMG radiation package
    - Prognostic cloud scheme
- **New runscripts**
- **Upgrade of DA**
  - Variational BC
  - Digital filter in the inner loop
  - pseudo-relative humidity at higher altitudes

- **Diagnostic package**
  - Wave spectrum
  - Bias

- **Upgrade EFS**
  - Higher resolution (T119L30 to T159L30) and 9-band ET, transitioned on 14 Sep, 2011

# NAVGEM: Long-term Plans

## Sep 2014

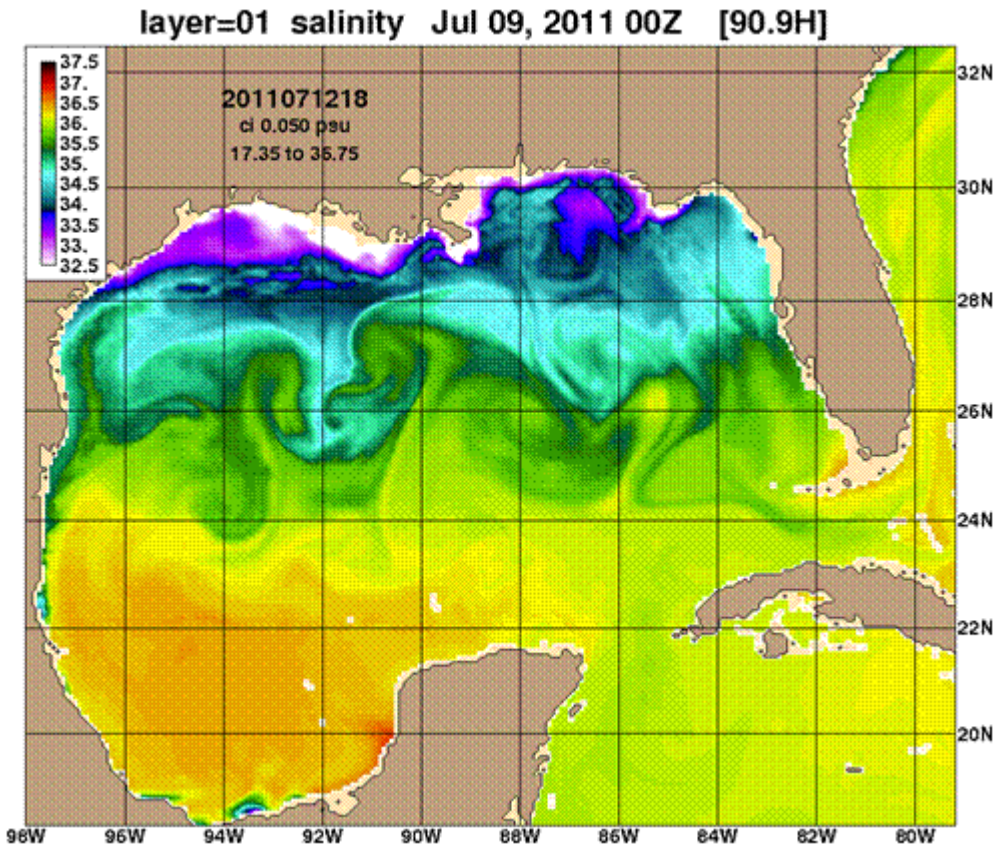
- **Variational-Ensemble Hybrid Data Assimilation**
- **Dynamic Core**
  - **Higher resolution (T600+L60+)**
  - **Model top at mesopause (~90 km)**
  - **ESMF super-structure framework**
  - **Coupling with HYCOM (FY12-14)**
- **Advanced Physics:**
  - **Prognostic Clouds (FY13)**
  - **New Radiation scheme (FY12)**
  - **Convective and Mid-upper atmospheric gravity wave drag**
  - **New land surface model and data assimilation (FY13)**

# Next Generation: Global Hybrid Coordinate Ocean Model (G-HYCOM)

- Next generation dynamic model
- POM-based / variable vertical coordinates
- NOPP Consortium
  - NRL lead,
  - U Miami, Los Alamos, French, NOAA/AOML, etc.
- Forecasts 3D Temperature, Salinity, Currents, Elevation
  - To 120 hours
  - ESMF backbone
- Initial global resolution 1/12 deg (2010)
  - Final resolution 1/25 deg (2014)
  - 40+ vertical layers
  - Pressure, depth, sigma coordinates as needed
- FNMOC NOGAPS atmospheric forcing
- Assimilates SST / SSH / surface obs / profile data – using NCODA
- Planned to replace global NCOM & some regional domains
  - Running pre-operational at NAVOCEANO
  - VTR completed
  - OPTEST FY11
- Global service to NOAA, others

Surface Salinity (30 days)

NRL Stennis graphics




**1/12** (9 km / 5 nm) → **1/25 deg** (3.8 km / 1.8 nm) in 2014

# COUPLED COAMPS/NCOM

- This joint OPTEST is the first of its kind. It evaluates
  - The ESMF 2-way coupled atmosphere-ocean configuration of COAMPS-OS
  - Concurrent installations at FNMOC and NAVOCEANO under a joint CONOPS.
- The primary OPTEST objectives
  1. Ensure that the system is ready for transition from R&D to operations (TRL-9)
  2. Demonstrate that COUPLED COAMPS can provide Fleet support that is equal to or better than the current capabilities.
- This is a functional evaluation — the science behind this configuration of COAMPS has been reported in the previously approved Validation Test Report (VTR).
- **These OPTEST results show that the ESMF-COUPLED COAMPS system is as good as or slightly better than the current operational COAMPS (atmosphere) and NCOM (ocean) capabilities.**

# Watchfloor of the Future

WoTF level of work determination model parameters include:
Seas 12ft or greater;
Winds 30kts or greater;
Thunderstorms likely;
Severe Thunderstorms likely;
Snowfall 4" or greater over 24hrs;
Excessive rainfall - l"/hr and/or 3"/24hrs; and
Mode1 uncertainty for weather system of interest (i.e., surface low pressure) timing, track, and intensity.
*(Note: Parameters are in 12 hour intervals out to 10 days.*

Visualization shall allow simultaneous and selectable overlays of model parameters with current and projected ship positions, fixed fleet OP-AREAS, standard aviation routes, fixed CNIC installations, and the following METOC overlays:
High winds and seas warnings;
Tropical Warnings; and
EFS or other ensemble generated Gale and 12' Seas probability charts.

Determination of WoTF Level 3 decision engagement will be the intersection of fleet assets present in areas of destructive weather and where significant model uncertainty exists.

# FNMOC Climo Requests

- 1. Monthly Winds
- 2. Monthly Waves
- 3. Monthly precipitation
- 4. Daily archived winds/waves for forensics research
- 5. Ceilings/visibility
- 6. EM ducting (dM/dz profile)
- 7. Tropical Cyclones tracks
- 
- - For all but 4), monthly averages are sufficient.
- 
- - Filtering on 'predictable' climatological events such as El Nino or the Arctic Oscillation can allow for better estimates, but reduce the samples, so the statistical significance should be provided.
- 
- - Resolution requirements vary widely, depending on the mission and the parameters. In many cases, our dataset horizontal resolution is insufficient to provide a useful product. For EM applications, both the horizontal and vertical resolution are never sufficient in climate reanalyses or models. Some type of "downscaling" is required.
- 
- - Thresholding of parameters is often required. Sometimes the focus is on extreme, low probability event

# Ocean Prediction Requirements

- Not documented well, but the fleet asks frequently for predictions beyond the present 3-5 day forecasts
  - Presently use historical model runs or observation based climatologies such as GDEM (temperature/salinity)
  - Need to have a conditional climatology of temperature/salinity/currents
  - Need a method to blend the short term forecasts with the appropriate climatology

- Presently we measure model skill against in-situ measurements of temperature and salinity, in particular, the vertical gradients of these parameters.

# TFCC ESPC Requirements

- • Projected tropical cyclone frequency and intensity
- • Regional sea level rise projections and methodologies to predict
- • Aerosols, dust, smoke, and soot - another substantial uncertainty in predictions of future climate
- • Clouds - Current climate models do not represent cloud physics well
- • Ocean circulation – large uncertainties in predictions of future ocean changes (historical data is lacking)
- • Precipitation - Scientists and policymakers to use climate models to assess regional changes
- • Developing a range of model types (e.g., statistical, dynamical, statistical dynamical, multi-model)
- • Improving the physics in models of sea ice, ice sheets, the atmosphere, the ocean, permafrost, and coastal zones - Reducing and quantifying the uncertainties of these physical models
- • Providing probabilistic output from climate models and in climate assessments
- • Sea ice extent and thickness
- • Linking the poles (air/met and ocean) to global models – including a more refined polar prediction in and of itself
- • Providing climate assessments on a 5-10 year basis for FYDP cycle decisions
- • Climate models that focus on the 30 year recapitalization cycle and not just 50-100 year climate models.